Differences of Water Quality of Upstream and Downstream Tidal River in Gasing River South Sumatra, Indonesia

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Abstract. Banyuasin Regency, which part of its territory is tidal land, like the Gasing River. The data used secondary data using SPSS. Most of the results of pH measurements were the range 2.82 – 5.75. The COD parameters are all above the quality standard. For TDS, DO, BOD, and TSS all are still below the quality standard. Heavy metal parameters such as Fe-T of the year there are concentrations of more than the quality standard. In addition, Cu-T is all above the quality standard. Results of comparative analysis of water characteristics at pH, temperature, TDS, DO, BOD, COD and TSS. The results of comparative analysis of Zn-T, Fe-T, Cd-T, Pb-T, and Cu-T found no differences in all conditions. The moderate pollution index was found in the downstream part of the April 2017 measurement of 6.54. While other data shows a light pollutant index with a value range of 1.17-4.80.

Keywords: Gasing River, water quality, heavy metals, water characteristics, tides

1 Introduction

Banyuasin Regency, one of the coastal areas of the East Coast of South Sumatra, is an estuary area [1]. Part of Banyuasin's territory is tidal land [2]. Tide occurs when the sea level is higher than the river (tide), the tidal current will flow into the river. Low tide occurs when the sea level is lower than the river, tidal currents will flow into the sea [3]. One of the river conditions like this is the

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Gasing River. Tidal hydrological characteristics have an impact on river water quality [4]. Coupled with the banks of the Gasing River, there are several active companies along this river. These companies include: wood processing industries, rubber [5], fertilizers, ceramics, ship docks, detergents, oil, gas, cold storage, electroplating and the soft drink industry as well as water transportation activities [6]. Sungai Gasing is also used by several of these companies as recipients of final waste disposal [7].

Activities that exist along the Gasing River can pollute the water either by natural processes or anthropogenic activities [8]. Solid or liquid waste discharged into river bodies can result in water toxicity, eutrophication, and damage to aquatic life [9]. Metals can be lead, mercury, cadmium, copper, iron, zinc and manganese. This metal is very toxic and can harm the environment if it exceeds quality standards [10]. Heavy metal concentrations can affect marine biota [11]. So that heavy metal pollution must be detected early, because the effects can damage ecosystems and public health [12]. With tidal conditions, of course the water does not only flow downstream but sometimes upstream. This situation will make the concentration of contaminants different from the usual places which only flow downstream. Based on the above, the authors will analyze the differences in pollutant concentrations in the upstream and downstream and look at the differences in water concentrations at the beginning of the year (rainy season) and the end of the year (dry season). The parameter are total suspended solids content (TSS), total dissolved solids (TDS), dissolved oxygen (DO), Potential Hydrogen (pH), biochemical oxygen demand (BOD), chemical oxygen demand (COD), Iron (Fe), Cadmium (Cd), Copper (Cu), Zinc (Zn) and Lead (Pb). Besides that, it will analyze the pollution index in the Gasing river.

2 Materials and Methods

2.1 Study location

Data analysis was carried out in Gasing River, Banyuasin Regency, South Sumatra Province, Indonesia. The data used in this study is secondary data from 2017 to 2021. The data is taken from an annual report conducted by the Banyuasin Regency Environmental Service.

2.2 Sampling method

Water samples were taken from the Gasing River, Banyuasin Regency, divided into 2 stations, namely upstream in the location 2°49'13.2"S 104°41'24.9"E and downstream in the location 2°49'22.0"S 104°40'43.7"E. At each station, water samples for temperature measurement refer to SNI 6989.23-2005 and several parameters are tested according to the Indonesian National Standard (SNI), namely: TSS (SNI 6989.3:2019), TDS (SNI 6989.27:2019), DO (SNI 06-6989.14-2004), pH (SNI 6989.11:2019), BOD (SNI 6989.72:2009), COD (SNI 06-6989.2-2004). In addition, there are several parameters of heavy metals that are measured, namely: Fe (SNI 6989.4:2009), Cd (SNI 6989.16:2009), Cu (SNI 6989.6:2009), Zn (SNI 6989.7:2009) and Pb (SNI 6989.8:2009). The results of the sample analysis for each parameter were compared with the quality standards based on the South Sumatra Governor Regulation [13].

2.3 Data analysis

Data analysis was carried out to see a comparison of measurement results at the beginning and at the end of the year, upstream and downstream of the Gasing River. Data were analyzed using an independent t test with an alpha error rate of 5% (0.05), where if a p value ≤ 0.05 is obtained, there is a difference. Data analysis using SPPS.

2.4 Pollution index

Pollution index (PI) is carried out to see the level of quality pollution of the Gasing River. The data used are the results of measurements in 2021. The criteria for pollution levels are categorized as: good ($0 \leq Pij \leq 1.0$), lightly polluted ($1.0 < Pij \leq 5.0$), moderately polluted $5.0 < Pij \leq 10$,0), and heavily polluted ($Pij \geq 10$) [14].

3 Results and Discussions

3.1 Characteristics of Gasing River water

Based on the results of Gasing River water monitoring data from 2017 to 2021, the data is divided into two parts, namely the concentration of water characteristics and the concentration of heavy metals. At the beginning of the year from February to April is the rainy season. March is included in the category of high rainfall, amounting to 344 mm and in April, the average category of rainfall is 242 mm [15]. Gasing River water characteristic data can be seen in the table below:

Table 1. Characteristics of Gasing River water parameters pH, temperature, TDS, DO, BOD, COD and TSS at upstream and downstream locations at the beginning and end of 2017 to 2021

Location	Group	Time Sampling	Ph	Temp	TDS	DO	BOD	COD	TSS
Upstream	Beginning of year	April 2017	**5.65**	23	94	**1.62**	**7.72**	**14.77**	24
		February 2018	**5.48**	28	126	6.04	**4.82**	**19.3**	26
		March 2019	**5.75**	26	83	6.44	1.61	**13.4**	34
		February 2020	**5.65**	**23**	94	**1.62**	**7.72**	**14.77**	24
		February 2021	6.36	29	112	6.44	1.32	**10.8**	14.5
	End of year	October 2017	**5.6**	**24**	177	**1.74**	**2.4**	**29.8**	20
		October 2018	**5.6**	**24**	177	**1.74**	**2.4**	**29.8**	20
		September 2019	6.15	**24**	179	6.84	0.841	7.01	22.3
		November 2020	6.15	**24**	179	6.84	0.841	7.01	22.3
		November 2021	**5.92**	26	88	6.44	1.99	**20.1**	2
Downtream	Beginning of year	April 2017	**2.94**	**23**	106	**3.04**	1.61	9.6	26
		February 2018	**4.42**	25	109	7.25	1.58	4.39	6.5
		March 2019	**4.2**	26	73	6.84	1.25	9.56	26
		February 2020	**4.42**	25	109	7.25	1.58	4.39	6.5
		February 2021	**4.4**	28	81	6.84	1.85	**13.2**	34.6
	End of year	October 2017	**4.89**	26	121	**4.07**	**5.61**	**18.3**	16
		October 2018	**4.89**	26	121	**4.07**	**5.61**	**18.3**	16
		September 2019	6.07	25	142	6.84	0.768	6.41	20.7
		November 2020	**2.82**	28	27	6.44	1.19	8.15	2.4
		November 2021	**2.82**	28	27	6.44	1.19	8.15	2.4
Quality standards (13)			6-9	± 3	1000	6	2	10	50
Unit			-	˚C	Mg/L	Mg/L	Mg/L	Mg/L	Mg/L

Based on the table above, most of the pH parameters are in an acidic state, namely the range of 2.82 – 5.75. Acidic water conditions at the beginning of the year both in the upstream and downstream areas of the Gasing River. Temperatures below 25 ˚C are most dominant in the upstream at the end of the year. TDS is still safe under the quality standard at all monitoring points and years. For DO there are several points and years of measurement where DO is lower than the Quality Standard. For BOD, the same as DO, there are several points and years of measurement. For COD in the upstream and early years of measurement everything is above the quality standard. For TSS everything is still below the quality standard.

Physical and chemical parameters related to changes in water level. Water level tends to be positively correlated with temperature (WT). During the high water period the water is turbid and the pH is higher than DO. As for temperature, EC, DO are low in the dry season [16]. A certain amount of rainfall, this study was 30 mm, must occur in order to carry pollutants from the surface into bodies of water. Rainfall events after a long dry season accelerate the decline in water quality because pollutants can accumulate on the surface during the dry season [17]. Meanwhile, the research results of Hashim et al (2022) showed that there was no effect of the weather on the pH value of the Garang River water quality [18].

Table 2. Heavy metal concentrations in Gasing River water parameters Zn-T, Fe-T, Cd-T, Pb-T, and Cu-T at upstream and downstream locations at the beginning and end of 2017 to 2021

Location	Group	Time Sampling	Zn-T	Fe-T	Cd-T	Pb-T	Cu-T
Upstream	Beginning of year	April 2017	<0.007	0.193	<0.003	<0.026	<0.009
		February 2018	<0.007	**3**	<0.003	<0.026	<0.009
		March 2019	<0.013	**4.119**	<0.014	<0.026	**0.034**
		February 2020	<0.007	0.193	<0.003	<0.026	<0.009
		February 2021	0.011	**1.01**	0.012	0.19	**0.053**
	End of year	October 2017	<0.007	**2.12**	<0.003	<0.026	**0.095**
		October 2018	<0.007	**2.12**	<0.003	<0.026	**0.095**
		September 2019	<0.013	<0.081	<0.014	<0.026	**0.026**
		November 2020	<0.013	<0.081	<0.014	<0.026	**0.026**
		November 2021	0.011	0.079	0.013	0.19	**0.053**
Downtream	Beginning of year	April 2017	0.012	**12.8**	<0.003	<0.026	<0.009
		February 2018	<0.007	**0.441**	<0.003	<0.026	<0.009
		March 2019	<0.013	**1.51**	<0.014	<0.026	**0.14**
		February 2020	<0.007	**0.441**	<0.003	<0.026	<0.009
		February 2021	0.011	0.08	0.012	0.19	**0.053**
	End of year	October 2017	<0.007	**0.715**	<0.003	<0.026	**0.129**
		October 2018	<0.007	**0.715**	<0.003	<0.026	**0.129**
		September 2019	<0.013	<0.081	<0.014	<0.026	**0.032**
		November 2020	0.011	0.079	0.012	0.19	**0.053**
		November 2021	0.011	0.079	0.012	0.19	**0.053**
Quality standards (13)			0.05	0.3	0.1	0.3	0.02
Unit			Mg/L	Mg/L	Mg/L	Mg/L	Mg/L

Based on the table above, the Fe-T parameter in the upstream at the beginning of the year and downstream at the beginning of the year there is a concentration of more than the quality standard. In addition, Cu-T is also at all points upstream at the end of the year and downstream at the end of the year, all above the quality standard. While the Zn-T, Cd-T and Pb-T parameters are all still safe, namely below the quality standard in all areas and years of measurement.

The concentration of heavy metals in the rainy season water is slightly lower than the dry season water. This occurs because the concentration of heavy metals reacts quickly to rainfall, resulting in a decrease [19]. This is confirmed that the concentration and type of metals are affected by rainy and dry periods [20]. Meanwhile, the results of Akomaye's study (2018) show no difference in heavy metal concentrations in the rainy and dry seasons. This shows that the source is indiscriminate disposal of metal waste and not from sources of air pollution [21].

3.2 The results of the comparative analysis of water characteristics

Based on the results of Gasing River water monitoring data from 2017 to 2021, water quality data will be compared based on the early-year and end-of-year groups in the upstream (table 3), early-year and end-of-year groups in the downstream (table 4), groups upstream and downstream (table 5). The results of the comparative analysis can be seen in the table below:

Table 3. Differences at the beginning of the year and at the end of the year in the water characteristics with the parameters pH, temperature, TDS, DO, BOD, COD and TSS in the upstream

Parameters	Group	n	Mean	SD ±	SE	P Value	Conclusion
pH	Beginning of year	5	5.78	0.34	0.15	0.603	No different
	End of year	5	5.88	0.28	0.12		
Temp	Beginning of year	5	25.80	2.78	1.24	0.334	No different
	End of year	5	24.40	0.89	0.40		
TDS	Beginning of year	5	101.80	17.07	7.63	0.018	Different
	End of year	5	160.00	40.26	18.00		
DO	Beginning of year	5	4.43	2.57	1.15	0.868	No different
	End of year	5	4.72	2.73	1.22		
BOD	Beginning of year	5	4.64	3.13	1.40	0.103	No different
	End of year	5	1.69	0.80	0.36		
COD	Beginning of year	5	14.61	3.08	1.38	0.473	No different
	End of year	5	18.74	11.42	5.11		
TSS	Beginning of year	5	24.50	6.95	3.11	0.186	No different
	End of year	5	17.32	8.64	3.86		

Based on the table above, there are differences in the TDS parameters, while in the parameters pH, temperature, DO, BOD, COD and TSS there are no differences at the beginning of the year and the end of the year in the upper reaches of the Gasing River. During the rainy season, the physical and chemical parameters of the water level at the estuary of the Serayu River are higher than the rainy season (22). For water quality in 2008, there were significant differences between the dry season and the rainy season for 17 water quality parameters except TP, NO 3, Fe 2þ and Zn 2þ. The parameter levels of pH, EC, CODMn, BOD 5, NHþ 4, SO 2 4, and Cl in the dry season were much higher than in the rainy season. In the dry season, river water quality variations are mainly influenced by domestic waste, industrial waste, and salt water intrusion. Whereas during the rainy season, apart from the sources of the pollutants mentioned above, drainage from agricultural land and livestock is also the main factor affecting water pollution (23).

Table 4. Differences at the beginning of the year and at the end of the year in the characteristics of the water with the parameters pH, temperature, TDS, DO, BOD, COD and TSS in the downstream

Parameters	Group	n	Mean	SD ±	SE	P Value	Conclusion
pH	Beginning of year	5	4.08	0.64	0.29	0.763	No different
	End of year	5	4.30	1.43	0.64		
Temp	Beginning of year	5	25.40	1.82	0.81	0.269	No different
	End of year	5	26.60	1.34	0.60		
TDS	Beginning of year	5	95.60	17.26	7.72	0.773	No different
	End of year	5	87.60	55.98	25.03		
DO	Beginning of year	5	6.24	1.80	0.81	0.527	No different
	End of year	5	5.57	1.38	0.62		
BOD	Beginning of year	5	1.57	0.21	0.10	0.311	No different
	End of year	5	2.87	2.50	1.12		
COD	Beginning of year	5	8.23	3.80	1.70	0.281	No different
	End of year	5	11.86	5.92	2.65		
TSS	Beginning of year	5	19.92	12.74	5.70	0.284	No different
	End of year	5	11.50	8.53	3.81		

Based on the table above there is no difference in the parameters of pH, temperature, TDS, DO, BOD, COD and TSS at the beginning of the year and the end of the year in the upper reaches of the Gasing River. Rainfall in the wet and dry seasons is different and the effect of rainfall dilution on pollutant concentrations and water flow transport affects the spatial distribution of water quality. There are significant differences in the spatial pattern of soil nutrients between the dry and rainy seasons, and soil nutrient content and surface runoff have a direct effect on water quality [24].

Table 5. Differences in upstream and downstream groups in water characteristics with parameters pH, temperature, TDS, DO, BOD, COD and TSS

Parameters	Group	n	Mean	SD ±	SE	P Value	Conclusion
pH	Upstream	10	5.83	0.30	0.09	0.001	No different
	Downtream	10	4.18	1.05	0.33		
Temp	Upstream	10	25.10	2.08	0.66	0.296	No different
	Downtream	10	26.00	1.63	0.52		
TDS	Upstream	10	130.90	42.32	13.38	0.045	Different
	Downtream	10	91.60	39.28	12.42		
DO	Upstream	10	4.58	2.50	0.79	0.173	No different
	Downtream	10	5.91	1.56	0.49		
BOD	Upstream	10	3.17	2.66	0.84	0.367	No different
	Downtream	10	2.22	1.81	0.57		
COD	Upstream	10	16.68	8.18	2.59	0.043	Different
	Downtream	10	10.05	5.07	1.60		
TSS	Upstream	10	20.91	8.30	2.63	0.252	No different
	Downtream	10	15.71	11.14	3.52		

Based on the table above, there are differences in the parameters of TDS and COD, while there are no differences in the parameters of pH, temperature, DO, BOD and TSS in the upstream and downstream of the Gasing River. Water quality in the dry season is better than in the rainy season, water quality in the upstream is better than in the downstream, and agricultural activities are a direct source of water pollution [24]. Differences in water quality in the upstream and downstream are especially evident during the summer and rainy seasons [25].The downstream DS sites are more seriously polluted than the corresponding upstream sites. The phenomenon of moderate eutrophication in the river channels in the basin illustrates the large impact of DS on water fluidity, which easily leads to nutrient enrichment in the river channels. More serious eutrophication at sites downstream of most of the DS is consistent with changes in WQ indicators with more serious downstream pollution [26]. overall shows the effect of tides and distance on water quality (TDS value) [27].

3.3 Results of heavy metal comparison analysis

Based on the results of Gasing River water monitoring data from 2017 to 2021, data on heavy metal concentrations will be compared based on the early-year and end-of-year groups in the upstream (table 6), early-year and end-of-year groups in the downstream (table 7), upstream and downstream groups (table 8). The results of the comparative analysis can be seen in the table below:

Table 6. Differences at the beginning of the year and at the end of the year in water characteristics with Zn-T, Fe-T, Cd-T, Pb-T, and Cu-T parameters in the upstream

Parameters	Group	n	Mean	SD ±	SE	P Value	Conclusion
Zn	Beginning of year	5	0.01	0.002	0.001	0.536	No different
	End of year	5	0.01	0.003	0.001		
Fe	Beginning of year	5	1.70	1.77	0.79	0.414	No different
	End of year	5	0.90	1.12	0.50		
Cd	Beginning of year	5	0.01	0.01	0.002	0.524	No different
	End of year	5	0.01	0.01	0.002		
Pb	Beginning of year	5	0.06	0.07	0.03	1.000	No different
	End of year	5	0.06	0.07	0.03		
Cu	Beginning of year	5	0.02	0.02	0.01	0.078	No different
	End of year	5	0.06	0.03	0.02		

Based on the table above there is no difference in the Zn-T, Fe-T, Cd-T, Pb-T, and Cu-T parameters at the beginning and end of the year in the upper Gasing River. All heavy metal concentrations were found to be lower in the rainy season than in the dry season, which is due to water dilution by rainfall, lower heavy metal uptake from diluted irrigation water, and heavy metal uptake from low concentration irrigation water and/or soil. Cluster analysis data of irrigation water, soil and vegetables revealed that heavy metals in vegetables were considered to be absorbed from irrigation water during the rainy season and from the soil during the dry season. During the dry season, high heavy metal concentrations in vegetables may be due to high bioconcentration factors (mostly >20%) [28].The results of the analysis show that during the rainy and dry seasons some heavy metal concentrations are above the literature level of typical soils [29].

Table 7. Differences at the beginning of the year and at the end of the year in the water characteristics with Zn-T, Fe-T, Cd-T, Pb-T, and Cu-T parameters in the downstream

Parameters	Group	n	Mean	SD ±	SE	P Value	Conclusion
Zn	Beginning of year	5	0.01	0.003	0.001	0.912	No different
	End of year	5	0.01	0.003	0.001		
Fe	Beginning of year	5	3.05	5.47	2.45	0.329	No different
	End of year	5	0.33	0.35	0.16		
Cd	Beginning of year	5	0.01	0.006	0.002	0.615	No different
	End of year	5	0.01	0.005	0.002		
Pb	Beginning of year	5	0.06	0.07	0.03	0.545	No different
	End of year	5	0.09	0.09	0.04		
Cu	Beginning of year	5	0.04	0.06	0.03	0.315	No different
	End of year	5	0.08	0.05	0.02		

Based on the table above, there is no difference in the Zn-T, Fe-T, Cd-T, Pb-T, and Cu-T parameters at the beginning and end of the year in the lower reaches of the Gasing River. Compared to the rainy season, we found that the metal content of the sediment was higher in the dry season. The mangrove sites showed significant metal accumulation rather than silt in both the wet and dry seasons. Geo-accumulation (Igeo) shows moderate pollution, possibly due to dilution due to runoff and tidal hydrodynamics in the rainy season. Increasing the concentration of all metals in the acid-soluble fraction and decreasing the metal content in the residual fraction occurred during the dry season. Risk studies show that Pb concentrations pose a higher environmental risk during the dry season [30].The results showed that the highest concentrations were recorded at the M-1 sampling point in both the dry and rainy seasons [31].

Table 8. Comparison of upstream and downstream groups on water characteristics with Zn-T, Fe-T, Cd-T, Pb-T, and Cu-T parameters

Parameters	Group	n	Mean	SD ±	SE	P Value	Conclusion
Zn	Upstream	10	0.01	0.003	0.001	0.808	No different
	Downtream	10	0.01	0.003	0.001		
Fe	Upstream	10	1.30	1.46	0.46	0.769	No different
	Downtream	10	1.70	3.93	1.24		
Cd	Upstream	10	0.01	0.01	0.002	0.902	No different
	Downtream	10	0.01	0.01	0.002		
Pb	Upstream	10	0.06	0.07	0.02	0.628	No different
	Downtream	10	0.08	0.08	0.03		
Cu	Upstream	10	0.04	0.03	0.01	0.303	No different
	Downtream	10	0.06	0.05	0.02		

Based on the table above, there is no difference in the Zn-T, Fe-T, Cd-T, Pb-T, and Cu-T parameters in the upstream and downstream parts of the Gasing River. The combined water pollution index indicates more serious pollution downstream [32]. No significant changes were found in heavy metal concentrations at the upstream and downstream locations of the DS due to the low HRB concentrations. However, the similarity of aquatic communities upstream and downstream of the DS site is poor, indicating a large impact of DS regulation on WE [26]. The river can be affected by irregular sea tides, high for 6 hours and low for 7 hours. Different debits and flows result in differences in river water quality. At low tide the pollutant concentration will increase and vice versa [4].

3.4 Pollution index results

The Pollution Index is used to determine the level of pollution. The Pollution Index (IP) is determined for an allotment of a river. This Pollution Index (IP) can provide input to decision makers in order to assess the quality of water bodies. The results of the pollution index analysis based on measurement data for upstream and downstream locations, the early and end of the year groups from 2017 to 2021 (Table 9).

Table 9. Results of the upstream and downstream Pollution Index analysis of the Gasing River

Location	Group	Time Sampling	Pollution Index	Quality status
Upstream	Beginning of year	April 2017	2.85	Lightly polluted
		February 2018	4.33	Lightly polluted
		March 2019	4.80	Lightly polluted
		February 2020	2.85	Lightly polluted
		February 2021	2.67	Lightly polluted
	End of year	October 2017	3.86	Lightly polluted
		October 2018	3.86	Lightly polluted
		September 2019	1.17	Lightly polluted
		November 2020	1.17	Lightly polluted
		November 2021	2.28	Lightly polluted
Downtream	Beginning of year	April 2017	**6.54**	Moderately polluted
		February 2018	1.49	Lightly polluted
		March 2019	3.83	Lightly polluted
		February 2020	1.49	Lightly polluted
		February 2021	2.30	Lightly polluted
	End of year	October 2017	3.70	Lightly polluted
		October 2018	3.70	Lightly polluted
		September 2019	1.46	Lightly polluted
		November 2020	2.28	Lightly polluted
		November 2021	2.28	Lightly polluted

Based on the table above, obtained mild and moderate pollution indexes. The moderate pollution index was found in the downstream part of the April 2017 measurement of 6.54. While other data shows a light pollutant index with a value range of 1.17-4.80.

4 Conclusion

Most of the results of pH measurements were the range 2.82 – 5.75. The COD parameters are all above the quality standard. For TDS, DO, BOD, and TSS all are still below the quality standard. Heavy metal parameters such as Fe-T of the year there are concentrations of more than the quality standard. In addition, Cu-T is all above the quality standard. Results of comparative analysis of water characteristics at pH, temperature, TDS, DO, BOD, COD and TSS. The results of comparative analysis of Zn-T, Fe-T, Cd-T, Pb-T, and Cu-T found no differences in all conditions. The moderate pollution index was found in the downstream part of the April 2017 measurement of 6.54. While other data shows a light pollutant index with a value range of 1.17-4.80.

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